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(54) **FRACTIONATION OF SOYBEAN 7S GLOBULIN AND 11S GLOBULIN AND PROCESS FOR PRODUCING THE SAME**

(57) A method for fractionation of soybean protein into a 7S globulin-rich fraction and an 11S globulin-rich fraction which comprises treating a soybean protein-

containing solution with an enzyme or an enzyme preparation having an activity of decomposing phytic acid to thereby separate into a soluble fraction and an insoluble fraction at a specific pH value.

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## Description

## FIELD OF THE INVENTION

- 5   **[0001]** The present invention relates to a method for fractionating and a process for producing a 7S globulin-rich fraction and an 11S globulin-rich fraction from a soybean protein-containing solution.

## BACKGROUND ART

- 10   **[0002]** Soybean storage protein is precipitated at about pH 4.5 and can be relatively easily separated from components other than the protein. This is referred to as isolated soybean protein and, in many cases, soybean protein in this form is utilized in the food industry. The protein is further divided into 2S, 7S, 11S and 15S globulins according to sedimentation constants in ultracentrifugation analysis. Among them, 7S globulin and 11S globulin are predominant constituent protein components of the globulin fractions (note: 7S globulin and 11S globulin are classification names in a sedimentation method and substantially correspond to  $\beta$ -conglycinin and glycinin according to immunological nomenclature, respectively), and both of them have different specific properties such as viscosity, coagulability and surface activity. Then, fractionation of 7S globulin and 11S globulin makes it possible to utilize properties of respective protein components, and it is expected to increase industrial utilization of proteins.

- 15   **[0003]** 7S Globulin and 11S globulin are composed of several subunits. 7S Globulin is composed of three subunits, i.e.,  $\alpha$ ,  $\alpha'$  and  $\beta$  subunits. 11S Globulin is composed of several subunits each of which is a pair of an acidic polypeptide (A) and a basic polypeptide (B). The molecular weights and charge states of 7S globulin and 11S globulin are very similar to each other. In particular, both globulins are diversified due to combinations of subunits, and properties thereof range to some extent to thereby overlap each other. Then, for fractionating both globulins effectively, a certain essential difference needs to be found.

- 20   **[0004]** Known fractionation methods are as follows. That is, a method utilizing a difference in isoelectric point: extraction is carried out by adjusting pH to about the isoelectric point of 11S globulin and only 7S globulin is extracted (JP 55-124457 A); a method utilizing a difference in reactivity with calcium: a small amount of a calcium salt is added upon extraction to extract a 7S globulin-rich fraction (JP 48-56843 A); a method utilizing a difference in solubility at a certain pH and ionic strength: an insoluble fraction is removed in the presence of sodium chloride or potassium chloride at pH 1.2 to 4.0 to prepare 7S protein (JP 49-31843 A), or a slurry precipitated at an isoelectric point is adjusted to pH 5.0 to 5.6 and its molar concentration of sodium chloride is adjusted to 0.01 to 2 M to separate 7S and 11S fractions (JP 58-36345 A); and a method utilizing a cold-precipitation phenomenon and a reducing agent, etc.: this utilizes a phenomenon that the solubility of 11S globulin is lowered at a low temperature (referred to as cryo-precipitation phenomenon), and a soybean protein raw material is treated in the presence of a sulfurous acid compound, glutathione compound or cysteine compound in an aqueous system at pH 6.5 or higher, followed by adjusting pH to 5.5 to 7.0 and the temperature to 20°C or lower to fractionate into a 7S globulin-rich fraction and an 11S globulin-rich fraction (JP 61-187755 A).

- 25   **[0005]** These known fractionation methods skilfully utilize a difference in solubility between 7S globulin and 11S globulin due to pH, ionic strength, the presence of a certain salt, temperature, etc. However, there are problems that these known fractionation methods are unsuitable for an industrially applicable fractionation method because clear fractionation of both globulins cannot be achieved due to overlap of their properties as mentioned above or, even if clear fractionation can be achieved to some extent, these methods are still those for the level of experimental use. Thus, problems still remain in practice. For example, in the method of JP 61-187755 A, the cryo-precipitation phenomenon depends highly on the temperature and it is necessary to cool the reaction mixture to about 5°C, which results in a practical problem that a large amount of a sulfurous acid compound, etc. needs to be added to separate fractions with the low centrifugal force industrially available, as well which results in a problem of fractionation precision that a small amount of 11S globulin is contaminated in a soluble fraction.

- 30   **[0006]** Then, it has been desired to develop a fractionation method which can simply and effectively produce a 7S globulin-rich fraction and an 11S globulin-rich fraction on an industrial scale while minimizing contamination of the soluble fraction with the insoluble fraction or vice versa.

- 35   **[0007]** On the other hand, phytic acid is an organic phosphate compound (myo-inositol hexakis-phosphate: 6 phosphoric acid groups are attached to inositol) which is predominantly present in plant seeds in the form of its calcium salt, magnesium salt and potassium salt. Soybeans contain about 1% of phosphorus most of which is present in the form of phytin. Since phytic acid forms a slightly soluble compound by being attached to a nutritiously important mineral component (calcium, magnesium, iron, zinc, etc.) through a chelate bond, it is pointed out that phytic acid lowers absorption of these trace minerals in the living body. In addition, phytic acid tends to form a complex with a protein and a multivalent metal cation and, normally, soybean protein contains 1 to 3 % by weight of phytic acid based on the weight of the protein. The activity of decomposing phytic acid used herein refers to the activity for liberating phosphoric acid

from phytic acid. A representative enzyme having such an activity is phytase.

[0008] Utilization of phytase which has an activity of decomposing phytic acid of soybean protein is divided into that for removing phytic acid which is considered to be an inhibitor of mineral absorption and that for recovering a protein having high solubility under acidic conditions (pH 5 or lower). Examples of the former include those described in JP 49-7300 A, JP 50-130800 A and JP 4-503002 A. Examples of the latter include a method for isolating a soluble protein fraction from a phytic acid-containing protein material which comprises adding phytase to an aqueous suspension of a phytin-containing soybean protein material to decompose phytin, adjusting the suspension to pH about 4.6 to form an insoluble precipitate, collecting a protein solution, adjusting the protein solution to pH about 5.0 to 5.4 to precipitate a protein fraction and collecting the precipitated protein fraction (JP 48-18450 A); and a method for collecting a protein from a vegetable protein raw material which comprises washing the vegetable protein raw material with water at an isoelectric point, digesting the washed vegetable protein raw material with acidic phytase, and separating a soluble protein-containing liquid extract from an insoluble digested residue to collect the protein (JP 51-125300 A).

[0009] Phytase is reacted under the following conditions (extracted from Examples of each publication). JP 49-7300 A: endogenous phytase, pH 5, 65°C., 9.3 hours; JP 50-130800 A: wheat phytase, pH 5.5, 45°C, 16 hours; JP 4-503002 A: microorganism phytase, pH 5.0, 40°C, 4 hours; JP 48-18450 A: wheat phytase, pH 6, 50-55°C, 24 hours; and JP 51-125300 A: microorganism phytase, pH 2.8, 50°C, 10 hours.

[0010] Since bacteria generally tend to grow at pH 5 or higher, normally, a solution containing soybean protein is liable to be putrefied unless it is subjected to sterilization treatment such as heat sterilization, etc. In addition, since a protein is liable to be denatured with an acid by treatment under strong acidic conditions such as at pH 2.8 for a long period of time, such treatment adversely affects fractionation of 7S globulin and 11S globulin. Further, in the method of JP 51-125300 A, the dissolved fraction is fractionated from the "okara (insoluble residue from soybean milk or tofu production)" component after treatment with phytase. Therefore, this does not teach acceleration of fractionation of 7S globulin and 11S globulin.

#### Objects of the Invention

[0011] An object of the present invention is to propose a novel fractionation method and a production process for 7S globulin and 11S globulin, wherein an enzyme is utilized. Another object of the present invention is to provide a fractionation method having high fractionation precision while minimizing the contamination rate of respective fractions, which can simply and efficiently carry out the production of both fractions on an industrial scale.

#### Summary of the Invention

[0012] As a result of the present inventors' intensive study, the following have been found.

[0013] It has been found that fractionation capability of 7S globulin and 11S globulin is improved by treatment with phytase, which is an enzyme having an activity of decomposing phytic acid, at a certain pH. Further, it has also been found that, when a soybean protein-containing solution is treated with an enzyme or an enzyme preparation having an activity of decomposing phytic acid to decompose phytic acid and phytates contained therein, followed by separating them at an appropriate pH range, a 7S-rich fraction can be simply and readily passed into a soluble fraction, while passing an 11S-rich fraction into an insoluble fraction without overlapping each other at room temperature without addition of a reducing agent, etc. Thus the present invention has been completed. Although the mechanism of this phenomenon is not fully elucidated, it is considered that phytic acid and phytates, which form a complex with a protein and a multivalent metal ion, are decomposed by treatment with phytase so as to cause a change in the solubility behavior of 7S globulin and 11S globulin, thereby increasing the difference in their solubility at a specific pH, which makes their fractionation possible.

[0014] The present invention is a method for fractionation or a process for producing a 7S globulin-rich fraction and an 11S globulin-rich fraction which comprises treating a soybean protein-containing solution with an enzyme or an enzyme preparation having an activity of decomposing phytic acid and separating it into a soluble fraction and an insoluble fraction at a specific pH.

#### Detailed Description of the Invention

[0015] Hereinafter, preferred embodiments of the present invention will be described. Soybean protein used in the present invention is preferably that from which insoluble residue ("okara") has been removed. Examples thereof include soybean protein such as soybean milk (including dried soybean milk powder), isolated soybean protein and the like, whose protein is native or with little denaturation, that is, soybean protein which is processed lightly without denaturation, or with minimal denaturation. In general, defatted-soybeans obtained by extraction with n-hexane at low temperature are suitable as a starting material. In particular, defatted-soybeans, which are scarcely denatured and have

a nitrogen solubility index (NSI) of 60 or more, preferably 80 or more, are preferred. Preferably, defatted-soybean milk and isolated soybean protein obtained from such scarcely denatured defatted-soybeans are used in the present invention.

**[0016]** In addition, it is preferred to avoid protein denaturation due to heating and severe conditions (e.g., strong acidic or strong alkaline conditions, etc.) as much as possible during the production steps (e.g., extraction step, step for adjusting pH, etc.). Preferably, a heat sterilization step is also avoided. Normally, the phytic acid content of a solution containing the thus-obtained soybean protein without denaturation or with little denaturation is 1 to 3% by weight based on the weight of the protein.

**[0017]** Whether protein in a soybean protein-containing solution is denatured with heat, etc. or not can be judged by analysis of the protein by Differential Scanning Calorimetry (DSC) (Nagano *et al.*, J. Agric. Food Chem., 40, 941-944 (1992)). According to this analysis, for example, respective endothermic peaks derived from its main constituent components, 7S and 11S globulins, can be recognized in the case of isolated soybean protein which is not denatured. However, when isolated soybean protein undergoes excess denaturation, no endothermic peak derived from the constituent components is observed. Therefore, the presence or absence of denaturation can be readily judged.

**[0018]** The enzyme or the enzyme preparation having an activity of decomposing phytic acid to be used in the present invention is not specifically limited and there can be used enzymes such as phytase, phosphatase, etc. which have an activity of decomposing phytic acid and are derived from vegetables such as wheat, potato, etc.; animal organs such as the intestinal tracts, etc.; and microorganisms such as bacteria, yeast, mold, actinomycetes, etc. Preferably, the enzyme or the enzyme preparation to be used has no or less protease activity because protease activity causes not only interference with fractionation of 7S globulin and 11S globulin due to hydrolysis thereof so as to change their solubility behavior, but also difficulties in recovery of 7S globulin and 11S globulin as proteins. For example, when there is no or less protein hydrolysis with protease activity, the TCA solubilization degree of soybean protein after treatment of the enzyme or the enzyme preparation can be defined as 20% or less, preferably 15% or less. The term "TCA solubilization degree" used herein is the ratio of the protein solubilized with 0.22 M trichloroacetic acid (TCA) to the total protein measured by a protein determination method such as the Kjeldahl method, Lowry method, etc. In general, the activity of decomposing of phytic acid of the enzyme or the enzyme preparation derived from bacteria is higher than that derived from vegetables, and the protease activity of the former is lower than the latter. Therefore, the former is advantageous with a view to prevention of hydrolysis and putrefaction of the protein.

**[0019]** For practising the present invention, it is necessary to treat a soybean protein-containing solution with the enzyme or the enzyme preparation having an activity of decomposing phytic acid to decompose phytic acid and phytates contained therein in order to fractionate into a 7S globulin-rich fraction and an 11S globulin-rich fraction. Although the degree of decomposition of phytic acid and phytates is not specifically limited, for example, preferably, the phytic acid content is reduced by 50% or more in comparison with that before treatment with the enzyme or the enzyme preparation. Therefore, the conditions of treatment with the enzyme or the enzyme preparation are not specifically limited in so far as the above conditions of each enzyme or enzyme preparation can be employed. Further, the treatment method is not specifically limited. However, in order to avoid denaturation of protein due to treatment under severe conditions and putrefaction due to treatment for a long period of time, the treatment time is preferably 5 minutes to 3 hours. When a certain measure for avoiding denaturation and putrefaction of protein is employed, treatment can also be carried out under conditions other than the above. For example, defatted-soybean with little denaturation is extracted with water and separated into a water insoluble fraction ("okara") and a water soluble fraction (soybean milk), and the water soluble fraction is subjected to decomposition of phytic acid at pH 3.5 to 9.0 and at a temperature of 20 to 70°C. The enzyme or the enzyme preparation having an activity of decomposing phytic acid may be added to the water soluble fraction after adjusting the pH of the fraction to 3.5 to 9.0. The amount of the enzyme or the enzyme preparation to be added ranges from 0.1 to 100 unit/g, preferably from 0.5 to 50 unit/g and, normally, treatment is continued for 5 minutes to 3 hours. Where treatment for a shorter period of time is desired, treatment can be carried out with the enzyme or the enzyme preparation having a higher concentration. One unit of phytase activity used herein is expressed by the amount of the enzyme which can liberate 1  $\mu$ mol of phosphoric acid from the substrate, phytic acid, during 1 minute in an initial stage of the reaction under conditions of pH 5.5 and at 37°C.

**[0020]** The degree of decomposition of phytic acid and phytates used herein was determined by measuring the amount of phytic acid in the solution directly. The amount of phytic acid was measured according to the method of Alii Mohamed (Cereal Chemistry, 63, 475, 1980).

**[0021]** When the soybean protein-containing solution after treatment of the enzyme or the enzyme preparation having an activity of decomposing phytic acid is adjusted to pH 5.6 to 6.6, preferably, pH 5.8 to 6.4, a 7S globulin-rich fraction and an 11S globulin-rich fraction can be readily separated. Since this process can be carried out regardless of separation temperature and addition of a reducing agent, separation can be carried out without a cooling step (cold precipitation) and addition of a sulfurous acid compound, glutathione compound or cysteine compound as described in JP 61-187755 A, and this is therefore an industrially effective process. However, contamination of the insoluble fraction with 7S globulin increases when pH is < 5.6, or contamination of the soluble fraction with 11S globulin increases when

pH is > 6.6. Then, no desired fractionation is expected. Preferably, when a soybean protein-containing solution is treated with the enzyme or the enzyme preparation at pH 5.6 to 6.6, more preferably pH 5.8 to 6.4, separation can be carried out more efficiently because re-adjustment of pH is not required.

[0022] Separation can be readily carried out by a known separation means (e.g., filtration, centrifugation, etc.), in particular, a continuous centrifugal separator (e.g., decanter) or the like. Of course, a non-continuous centrifugal separator such as a batch-wise one can also be used.

[0023] The state of fractionation of the 7S globulin-rich fraction and the 11S globulin-rich fraction according to the present invention can be evaluated based on a pattern obtained by SDS-polyacrylamide gel electrophoresis. In addition, for numerical expression of the amounts of 7S globulin and 11S globulin present in the insoluble and soluble fractions, respectively, their amounts were calculated based on the recovery rates of proteins in the insoluble and soluble fractions and the ratio of areas obtained by densitometry of the pattern obtained by SDS-polyacrylamide gel electrophoresis. 7S Globulin referred to herein is the total amount of  $\alpha$ ,  $\alpha'$  and  $\beta$  subunits and the 11S globulin content is the total amount of the acidic polypeptide (A) and the basic polypeptide (B).

[0024] After separation, the soluble fraction and the insoluble fraction can be used as such, or can further be subjected to concentration, neutralization, or drying for use as a 7S globulin-rich fraction and an 11S globulin-rich fraction. For concentration, preferably, a precipitated curd is separated and recovered by isoelectric point precipitation of the soluble fraction (pH 4.5-5.3, preferably pH 4.7-5.1) with a view to improvement of physical properties. Further, after isoelectric point precipitation, the curd can also be subjected to neutralization, heat sterilization treatment, or further, treatment with an enzyme such as protease, etc. A sterilized, powdered form is the most common product form. Heat sterilization treatment can also be carried out by known HTST treatment, UHT treatment and the like.

[0025] The following Examples specifically illustrate embodiments of the present invention, but are not to be construed to limit the scope thereof.

#### Example 1

[0026] To scarcely denatured defatted-soybeans (1 part by weight) (NSI 91), which was obtained by flaking soybeans and extracting their oil with an extraction solvent, n-hexane, to separate and remove the oil, was added water (7 parts by weight). The mixture was extracted at pH 7 at room temperature for 1 hour, and then centrifuged to obtain defatted-soybean milk. The soybean milk was adjusted to pH 6.2 with hydrochloric acid and warmed to 40°C. To this solution (phytic acid content: 2.20%/weight of protein; TCA solubilization degree: 8.6%) was added phytase ("PHYTASE NOVO L" manufactured by NOVO) in an amount corresponding to 8 units per the weight of protein and enzyme treatment was carried out for 30 minutes. After the reaction, the mixture treated with the enzyme (phytic acid content: 0.05%/weight of protein; TCA solubilization degree: substantially the same as that before the reaction) was centrifuged without changing pH at 6.2 by a batch-wise centrifugal separator (2,000 G) to obtain an insoluble fraction and a soluble fraction. At this time, the insoluble fraction and the soluble fraction were clearly separated. The temperature of the mixture during centrifugation was about 30°C. To the insoluble fraction was added water (2 parts by weight) and the mixture was neutralized with sodium hydroxide. On the other hand, the soluble fraction was adjusted to pH 4.8 with hydrochloric acid and the whey fraction was removed by centrifugation to obtain a precipitated curd. To the precipitated curd was added water (2 parts by weight) and the mixture was neutralized with sodium hydroxide. The respective neutralized fractions were sterilized at 140°C for 15 seconds, and spray-dried to obtain two fractionated soybean proteins.

[0027] Fig. 1 shows the pattern of SDS-polyacrylamide gel electrophoresis of the insoluble and soluble fraction of Example 1.

[0028] For numerical expression of the amounts of 7S globulin and 11S globulin present in the above-separated insoluble and soluble fractions, respectively, their amounts were calculated based on the recovery rates of proteins in the insoluble and soluble fractions and the ratio of areas obtained by densitometry of the pattern obtained by SDS-polyacrylamide gel electrophoresis. The results are shown in Table 1.

Table 1

	Soluble fraction	Insoluble fraction
Protein	55.2	44.8
7S	26.3	3.0
11S	1.0	34.9
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	1.8%	6.7%

[0029] The values in Table 1 were calculated by taking the total amount of protein before centrifugation as 100.

[0030] Contamination rate of soluble fraction = Amount of 11S in soluble fraction/Amount of protein in soluble fraction.

[0031] Contamination rate of insoluble fraction = Amount of 7S in insoluble fraction/Amount of protein in insoluble fraction.

[0032] (Hereafter, the values in the Tables were calculated in the same way).

#### Comparative Example 1

[0033] Defatted-soybean milk extracted in the same manner as that in Example 1 was adjusted to pH 6.2 with hydrochloric acid and then centrifuged with a batch-wise centrifugal separator (2,000 G). However, an insoluble fraction and a soluble fraction could not be separated clearly. Then, centrifugation was carried out with a batch-wise high speed centrifugal separator (10,000 G) to obtain an insoluble fraction and a soluble fraction. The temperature of solution during centrifugation was about 25°C.

[0034] Fig. 2 shows the pattern of SDS-polyacrylamide gel electrophoresis of the insoluble fraction and the soluble fraction of Comparative Example 1.

[0035] In the same manner as that in Example 1, the amounts of 7S and 11S globulins present in the insoluble and soluble fractions were calculated. The results are shown in Table 2.

Table 2

	Soluble fraction	Insoluble fraction
Protein	72.4	27.6
7S	30.3	2.0
11S	15.7	19.7
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	21.7%	7.2%

[0036] In Example 1, the fractions treated by phytase were clearly separated with a centrifugal force as low as 2,000 G. However, when no treatment with phytase was effected as in Comparative Example 1, 10,000 G was required for clear separation. Further, when the contamination rates of the soluble and insoluble fractions are compared, in Comparative Example 1, the contamination rate of 11S globulin in the soluble fraction is as high as 21.7% and the fractionation precision is not high. By contrast, in Example 1, the contamination rate of the fractions treated with phytase decrease to 1.9% and the fractionation precision is clearly improved.

[0037] These results show that treatment with phytase makes it possible to separate the soluble and insoluble fractions with the low centrifugal force industrially applicable and is useful for a fractionation method with a lower contamination rate.

#### Test Example 1

[0038] Defatted-soybean milk extracted in the same manner as that described in Example 1 was adjusted to pH 6.2 with hydrochloric acid and warmed to 40°C. To this solution was added phytase ("PHYTASE NOVO L" manufactured by NOVO) in an amount corresponding to 0.4 or 2 units based on the weight of protein, and enzyme treatment was carried out for 30 minutes. After the reaction, the mixture treated with the enzyme (phytic acid content: 1.83% or 0.87%/weight of protein) was centrifuged without changing pH at 6.2 by a batch-wise centrifugal separator (2,000 G) to obtain an insoluble fraction and a soluble fraction).

[0039] In the same manner as that in Example 1, the amounts of 7S and 11S globulins present in the insoluble and soluble fractions of Test Example 1 were calculated. The results are shown in Tables 3 and 4.

Table 3

(phytase corresponding to 0.4 unit)		
	Soluble fraction	Insoluble fraction
Protein	68.2	31.8
7S	27.6	1.5
11S	10.9	24.7

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Table 3 (continued)

(phytase corresponding to 0.4 unit)		
	Soluble fraction	Insoluble fraction
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	16.0%	4.7%

Table 4

(phytase corresponding to 2 units)		
	Soluble fraction	Insoluble fraction
Protein	57.5	42.5
7S	25.9	2.7
11S	1.5	31.2
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	2.6%	6.4%

[0040] As seen from these results, in the case of treatment with phytase for 30 minutes, as the amount of phytase to be added is higher, more improvement of fractionation is expected (provided that, when treatment with phytase is carried out for a longer period of time, a smaller amount of phytase can be used). The phytic acid content based on the weight of protein is 1.83% in the case of treatment with phytase in an amount corresponding to 0.4 unit, and 0.87% in the case of treatment with phytase in an amount corresponding to 2 units. When the reduction rate of phytic acid is calculated based on the phytic acid content before treatment with phytase (2.20%/weight of protein), it is 16.8% and 60.5%. Fractionation capability at 2,000 G is improved in either case. However, when 50% or more of the original phytic acid content is decomposed, fractionation precision is improved.

## Example 2

[0041] Defatted-soybean milk extracted in the same manner as that described in Example 1 was adjusted to pH 5.9 or 6.4 with hydrochloric acid and warmed to 40°C. To this solution was added phytase ("PHYTASE NOVO L" manufactured by NOVO) in an amount corresponding to 8 units based on the weight of protein, and enzyme treatment was carried out for 30 minutes. After the reaction, the mixture treated with the enzyme (phytic acid content of each solution: 0.05%/weight of protein) was centrifuged without changing pH by a batch-wise centrifugal separator (3,000 G) to obtain an insoluble fraction and a soluble fraction.

[0042] In the same manner as that in Example 1, the amounts of 7S and 11S globulins present in the insoluble and soluble fractions of Example 2 were calculated. The results are shown in Tables 5 and 6.

Table 5

(solution at pH 5.9)		
	Soluble fraction	Insoluble fraction
Protein	48.6	51.4
7S	28.1	3.6
11S	1.4	34.8
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	2.9%	7.0%

Table 6

(solution at pH 6.4)		
	Soluble fraction	Insoluble fraction
Protein	60.0	40.0
7S	28.6	2.1
11S	4.1	30.6
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	6.8%	5.3%

**[0043]** As seen from these results, the pH at which centrifugation is carried out, i.e., fractionation pH varies to some extent.

### Example 3

**[0044]** Defatted-soybean milk extracted in the same manner as that described in Example 1 was adjusted to pH 4.0 to 7.0 with hydrochloric acid and warmed to 40°C. To this solution was added phytase ("PHYTASE NOVO L" manufactured by NOVO) in an amount corresponding to 8 units based on the weight of protein, and enzyme treatment was carried out for 30 minutes. After the reaction, the mixture of pH 4.0 (phytic acid content: 0.05%/weight of protein) was adjusted to pH 6.2 with sodium hydroxide, and the mixture of pH 7.0 (phytic acid content: 0.08%/weight of protein) was adjusted to pH 6.2 with hydrochloric acid. Then, each mixture was centrifuged by a batch-wise centrifugal separator (3,000 G) to obtain an insoluble fraction and a soluble fraction.

**[0045]** In the same manner as that in Example 1, the amounts of 7S and 11S globulins present in the insoluble and soluble fractions of Example 3 were calculated. The results are shown in Tables 7 and 8.

Table 7

(phytase treatment at pH 4.0)		
	Soluble fraction	Insoluble fraction
Protein	39.8	60.2
7S	24.0	5.5
11S	1.0	34.5
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	2.5%	9.1%

Table 8

(phytase treatment at pH 7.0)		
	Soluble fraction	Insoluble fraction
Protein	61.7	38.3
7S	28.0	1.8
11S	5.5	26.2
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	8.9%	4.7%

### Example 4

**[0046]** Defatted-soybean milk extracted in the same manner as that described in Example 1 was adjusted to pH 4.5 with hydrochloric acid and centrifuged with a batch-wise centrifugal separator (2,000 G) to separate into an insoluble



fraction (hereinafter referred to as acid precipitated curd) and a soluble fraction (whey). To the acid precipitated curd (so-called isolated soybean protein) was added water and the curd was thoroughly dispersed. The dispersion was adjusted to pH 6.2 with sodium hydroxide. To this solution (phytic acid content: 1.80%/weight of protein) was added phytase ("PHYTASE NOVO L" manufactured by NOVO) in an amount corresponding to 8 units based on the weight of protein, and enzyme treatment was carried out for 30 minutes. This mixture treated with the enzyme (phytic acid content: 0.05%/weight of protein, no substantial change in TCA solubilization degree) was centrifuged with a batch-wise centrifugal separator (2,000 G) to obtain an insoluble fraction and a soluble fraction. At this time, the insoluble fraction and the soluble fraction were clearly separated. The solution temperature upon centrifugation was about 30°C. To the insoluble fraction was added water (2 parts by weight) and neutralized with sodium hydroxide. The soluble fraction as such was neutralized with sodium hydroxide. Each of them was sterilized at 140°C for 15 seconds and spray-dried to obtain fractionated soybean proteins. These fractionated soybean proteins had better flavor and taste and better color in comparison with conventional isolated soybean protein.

[0047] In the same manner as that in Example 1, the amounts of 7S and 11S globulins present in the insoluble and soluble fractions were calculated. The results are shown in Table 9.

Table 9

	Soluble fraction	Insoluble fraction
Protein	50.6	49.4
7S	32.1	3.1
11S	2.2	34.8
	Contamination rate of 11S	Contamination rate of 7S
Contamination rate	4.3%	6.3%

[0048] As seen from these results, when an acid precipitated curd (so-called isolated soybean protein) is used as a soybean protein-containing solution to be used for the fractionation, separation can also be carried out with good precision.

## Comparative Example 2

[0049] Defatted-soybean milk extracted in the same manner as that described in Example 1 was boiled in a boiling water bath for 10 minutes. After cooling with water, the solution was adjusted to pH 6.2 with hydrochloric acid and warmed to 40°C. To this solution was added phytase ("PHYTASE NOVO L" manufactured by NOVO) in an amount corresponding to 8 units based on the weight of protein, and enzyme treatment was carried out for 30 minutes. After the reaction, the mixture treated with the enzyme (phytic acid content: 0.05%/weight of protein) was centrifuged without changing pH by a batch-wise centrifugal separator (2,000 G). However, an insoluble fraction and a soluble fraction could not be separated clearly. Then, the mixture was centrifuged with a batch-wise high speed centrifugal separator (10,000 G) to obtain an insoluble fraction and a soluble fraction. However, separation into the insoluble fraction and the soluble fraction was not clear and the recovery rate of the insoluble fraction was as low as only 11%. Thus, it was clear that the heat treatment before treatment with phytase adversely affected the fractionation.

## Claims

1. A method for fractionating or a process for producing soybean 7S globulin and 11S globulin which comprises treating a soybean protein-containing solution with an enzyme or an enzyme preparation having an activity of decomposing phytic acid, and adjusting the solution to pH 5.6 to 6.6 to thereby separate into a soluble fraction which is a 7S globulin-rich fraction and an insoluble fraction which is an 11S globulin-rich fraction.
2. The method or the process according to claim 1, wherein the soybean protein to be treated with the enzyme or the enzyme preparation is that without denaturation or with little denaturation.
3. The method or the process according to claim 1 or claim 2, wherein the soybean protein-containing solution is treated with an enzyme or an enzyme preparation having an activity of decomposing phytic acid at a pH of 3.5 to 9.0 and a temperature of 20 to 70°C, for 5 minutes to 3 hours.

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4. The process according to any one of claims 1 to 3, wherein the fraction separated is neutralized, sterilized with heating and dried.

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Fig. 1

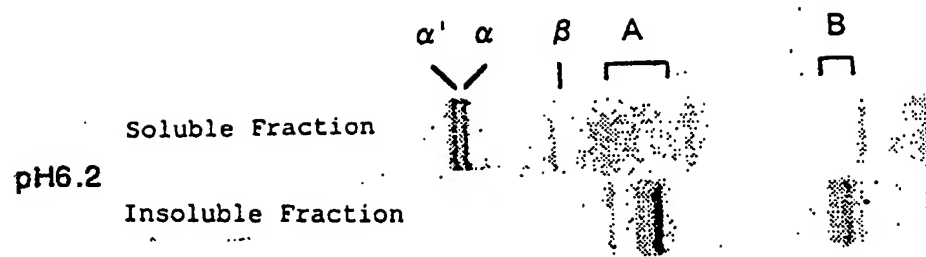
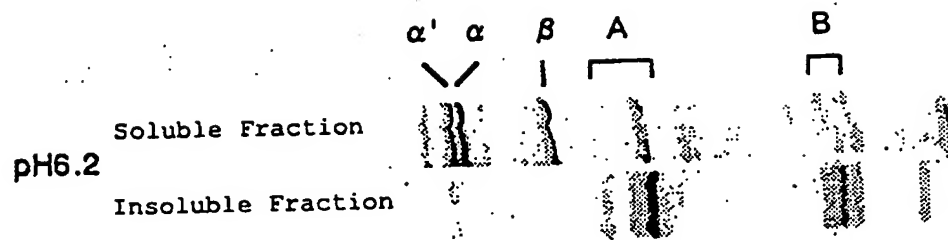


Fig. 2



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP00/02051

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. <sup>7</sup> C12P21/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl. <sup>7</sup> C12P21/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) BIOSIS (DIALOG), WPI (DIALOG)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 55-124457, A (Noda Sangyo Kagaku Kenkyusho), 25 September, 1980 (25.09.80) (Family: none)	1-4
A	US, 4370267, A (A.E. Staley Manufacturing Company), 01 January, 1983 (01.01.83) & JP, 58-36345, A & EP, 72094, A2	1-4
A	US, 4771126, A (Fuji Oil Company, Limited), 13 September, 1988 (13.09.88) & JP, 61-187755, A	1-4
A	JP, 50-130800, A (Asahi Chemical Industry Co., Ltd.), 16 October, 1975 (16.10.75) (Family: none)	1-4
A	US, 3733207, A (Soc. Prod. Nestle SA), 08 March, 1973 (08.03.73) & JP, 48-18450, A	1-4
A	WO, 90/8476, A (Alko Limited), 01 August, 1990 (01.08.90) & JP, 4-503002, A	1-4
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
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Date of the actual completion of the international search 05 June, 2000 (05.06.00)		Date of mailing of the international search report 13 June, 2000 (13.06.00)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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